6th International Conference on Renewable Energy Gas Technology REGATEC 2019, May 20th-21st 2019 in Malmö, Sweden

Biological CO_2-Methanation: an Approach to Standardization

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Supported by: Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Introduction

Power-to-Gas has been recognized globally as one of the key elements for the transition towards a sustainable energy system. Power-to-Methane (PtG-CH_4) is of special interest, since it can be easily integrated into the existing gas infrastructure and into well-established industrial and mobility applications. Biological CO_2-Methanation has reached industrial pilot scale and near-term commercial application. The increasing number of scientific articles covering novel approaches to improve biological systems shows the growing interest in this topic [1]. Unfortunately, the lack of coherent nomenclature hinders the comparability of existing studies at the moment.

Methodology

To overcome this limitation, we developed a robust parameter framework [2] to describe biological CO_2-Methanation. The basis for this was an extensive literature review and discussion rounds within the members of the ORBIT project [3], including academic and industrial entities, as well as a gas distribution system operator and an association for guideline preparation.

Power-to-Gas - Definitions and System Boundaries

As a basis, we defined system boundaries and mass and energy balances for all steps of the biological PtG-CH_4 technology illustrated in the figure. For the CO_2-Methanation step, we distinguish two subsystems: The CO_2-Methanation reactor system (yellow box) considers only the actual CO_2 conversion process and will allow the comparison of both academic and industrial methanation systems. The CO_2-Methanation process system boundary (green box) is better suited for industrial processes, because it additionally includes gas and liquid pre- and postprocessing steps that are usually present in such systems.

System parameters and Characteristic Variables

Based on the system boundary definitions, we define parameters to describe general system properties, e.g. size and volumes, as well as performance parameters, such as productivity and efficiencies. In addition, we introduce parameters to describe the biocatalyst and system costs. Finally, we provide recommendations on reference conditions to be used for system comparison. While the total set for system characterization consists of more than 80 parameters, a minimum list of basic parameters is provided in the Table.

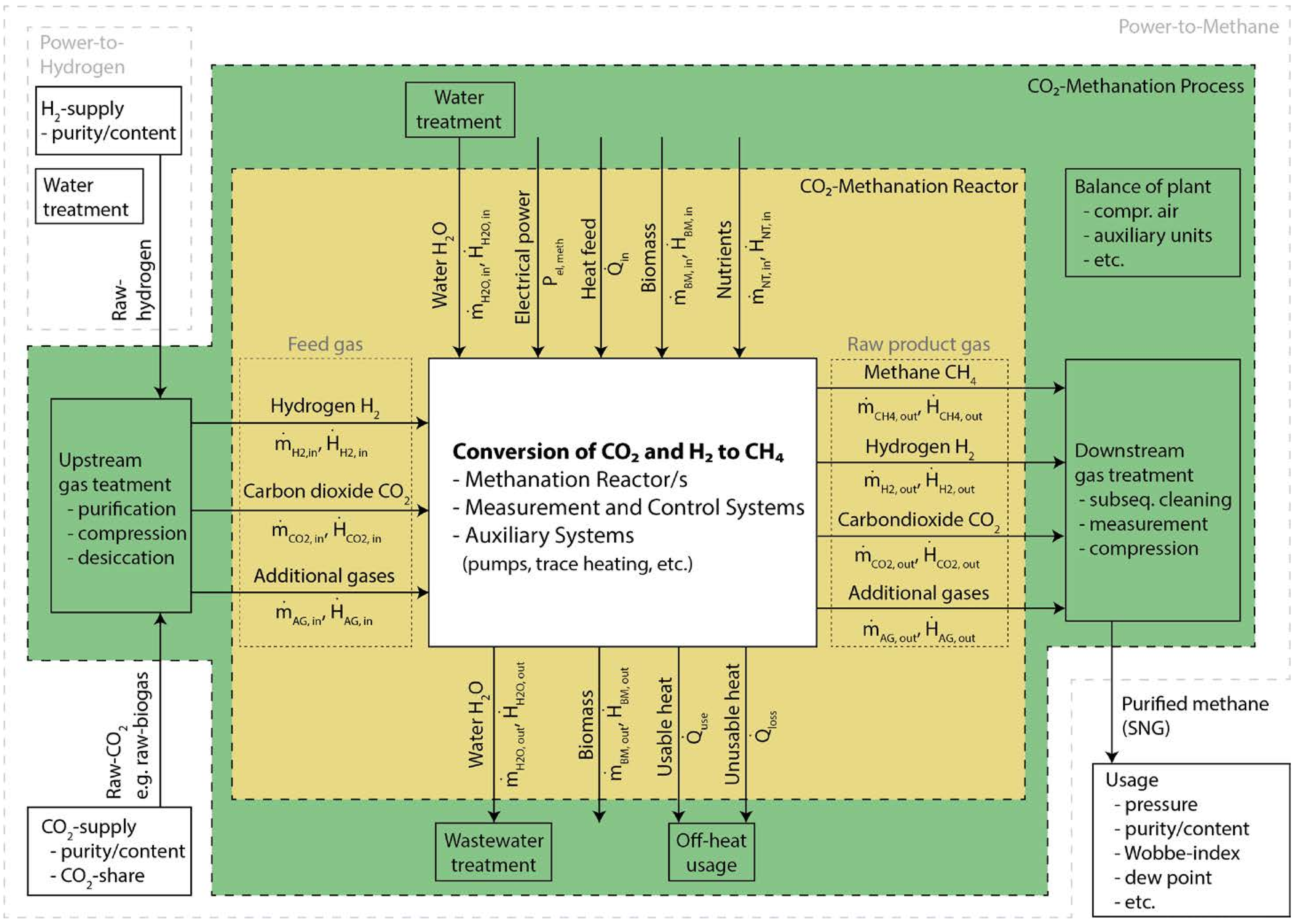

Figure 1: Boundaries, mass and energy streams of the systems CO_2-Methanation reactor (yellow), CO_2-Methanation process (green), Power-to-Hydrogen and Power-to-Methane.

Table: Basic parameters for methanation system description

Parameter	Unit
Reactor type	-
Reactor volume (V_R)	m^3
Nominal plant capacity (P_N)	kW
Maximum methane purity (mole fraction, $y_{CH4,out,max}$)	%
Nominal methane purity (mole fraction, $y_{CH4,out,N}$)	%
Methane production rate (MPR_R)	h^{-1}
Methane production rate (MPR_{LHV})	kW/h
Information on reactor inoculum	-
Reactor/process temperature ($T_{R,N}$)	°C
Reactor/process pressure ($p_{R,N}$)	bar(a)
Contact person biology & engineering	-

Conclusions

The need of a standardization is strongly supported by various PtX groups, including Power-to-Gas, Power-to-Liquid and Power-to-Chemicals. Based on the work described here, we are currently developing a publication and a guideline (VDI 4635), which will ensure a consistent and reliable comparison of biological and chemical CO_2-Methanation, as well as all PtG and PtX projects in the future.

References

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ORBIT-Partners: FENES at OTH Regensburg, Chair for Energy Process Engineering at FAU Erlangen-Nürnberg, Institute of Microbiology and Archaea Center at University of Regensburg, DVGW Research Centre at Engler-Bunte-Institute (EBI) of KIT, Electrochaea GmbH, MicrobEnergy GmbH, MicroPyros GmbH, Westnetz GmbH, innogy SE

Funding
This research was funded by the German Federal Ministry of Economic Affairs and Energy, grant number 03ET6125

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